

School Science

A Journal of Science Teaching in Secondary Schools.

EDITED BY C. E. LINEBARGER.

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School Science

VOL. I]

NOVEMBER, 1901.

[No. 6

THE LABORATORY AS A MEANS OF CULTURE.

BY W. L. POTEAT.

Professor of Biology, Wake Forest (N. C.) College.

Two agencies more than any others have contributed to the progress of science in the present century,—the organization of scientific societies and the equipment of scientific laboratories. The first served at once as a stimulus to ambition and industry and as a check upon hasty observation and unsupported theorizing. But valuable as this indirect agency has been, the laboratory, by its direct contributions to the increase of natural knowledge, has been even more powerful.

The essential feature of the laboratory method of instruction is that it brings the student into direct contact with nature. He does not study about nature; he studies nature. A book he values as a guide and help, but no matter with what authority it speaks, no matter how full and adequate the treatment, it is not allowed to come between him and his actual dealing with nature itself. The same is true of the teacher. His function is to stimulate, to make suggestions, to lead the way; and when he begins to retail to the learner what the learner can discover for himself, he in so far becomes rather a hindrance to scientific culture and subtracts from the total training which the laboratory would otherwise have given.

Indeed, there is no other way to become acquainted with the facts and laws of nature. The student who has not seen and handled acids and bases and salts does not know chemistry, no matter how full his text-book or lecture-notes. One who has merely read a book on botany is invariably confused and hesitating when he stands in the midst of plants. I once met at the seashore a lady who seemed to be familiar with zoölogy. I happened to have in my hand specimens of the common ascidian. She did

not recognize it. "Oh!" she exclaimed, "is that the ascidian? I have been reading so much about it and its bearing on the evolution theory."

But for the purposes of a liberal education the training which is incidental to the acquisition of the knowledge of nature is more important than that knowledge considered in itself. Now, what are the characteristics of the training given by laboratory courses? In the first place, the critical faculty is directly stimulated, and the observing powers are, of course, in constant exercise. The student acquires an intelligent respect for nature and for what is natural as opposed to what is merely formal and artificial. A wholesome self-reliance is cultivated. I have observed remarkable development in this respect in a single five months course. He learns to trust his own powers and grows strong in the assurance of first-hand knowledge. He tests and observes for himself, and receives nothing upon mere authority. No other exercise so develops the freedom and confidence of independent thinking. To these add manual skill and a certain equipoise and stability imparted to the whole round of mental accomplishments, and it will be seen that the laboratory as an instrument of culture is indispensable.

PHYSICS IN SECONDARY SCHOOLS.

BY CARL I. INGERSON.

Instructor in Physics, Normal and High School, St. Louis, Mo.

The proper place of physics in a course of study is predetermined by those characteristics which differentiate between it and other sciences. Were it not possible to fundamentally distinguish physics from the sciences generally, to draw a line of clear demarcation between natural philosophy and the other natural sciences, the prosecution of this branch of knowledge might be assigned indifferently to any period of the course, with equal promise of abundant achievements. But physics may be discriminated easily among the sciences, and he who fails to do so must either

*This paper was read in the Round Table Conference in Physics of the National Educational Association, Detroit, July 11, 1901.

accept the partial successes of his pupils, or else thank luck for results better than those which his lack of discernment entitled him to expect. Natural philosophy, the older designation of this science, is both apposite and illuminating. It implies philosophizing,—that is, reasoning like a lover of wisdom,—upon obvious phenomena in nature. Biology exercises the perceptive rather than the reflective faculties. It makes heavier demands upon memory than upon judgment. Chemist is alchemist, less its initial syllable; and chemistry, in rationalizing the mysteries of alchemy, has neither abrogated the imagination, nor circumscribed the range of its manifestations.

Nature study in the grammar schools could never rise to the dignity of a study of physics, even though natural phenomena engage the entire time and attention of the pupils. The necessary philosophic quality of mind is, to this class of learners, but a latent possession. That a child at nine years of age is a wholly different intellectual entity from the same child at twelve and sixteen is too patent to require demonstration; and I only state, categorically, that which you already know when I say that, at the earlier year in his life, perception and memory characterize his mental mode; a few years later imagination gives completion to the activities of his mind; while the reasoning, reflecting aspect of the intellect does not attain distinctiveness before the sixteenth year. The Jews had developed sound pedagogic practices more than twenty centuries ago. They recognized the processional incipencies of the cardinal mental endowments, and suited the pupil's tasks to the order of his psychic evolution. Thus, the first ten years of his life were devoted to the simple memorizing of their sacred writings; and not until they had passed their tenth birthdays were Jewish youths permitted to listen to the Rabbis and to question them concerning the Scriptures. Furthermore, in the adaptation of study to acquired capacity, it is said that the difficult book of the prophecies of Ezekiel was withheld from the Rabbis until they had attained the mature age of thirty years.

It is possible to propagate roses in January, and to produce ice in August; but nature refuses to coöperate. There are times and seasons in the intellectual as well as in the physical world.

Moreover, the student of physics ought to bring to his study

of the science not only potential but also certain kinetic mental energies. If the saying be true that "the calculus is the language in physics," it is equally true that algebra, geometry and trigonometry are the alphabet, and the two- and the three-syllabled words of the language. Or, to change the figure, mathematics is the machinery of thought, by which alone the most and the best truths of physics may be apprehended. Niagara without a wheel is not to be compared for usefulness as an efficient force to a spring brook supplied with a tiny "undershot." πR^2 ought to be more than a form, or formula, to the pupil who has to do with volumes, and the sine of the angle of incidence should be a sign reflecting some intelligible light.

Considering, therefore, the inexorable demands which the inherent nature of the science makes upon the thought processes of the pupils, the last years of the usual high-school course, in which their reason and judgment are in a state of natural, vigorous development, and in which also their mathematical attainments are as full as possible, surely present peculiar advantages for the study of the elements of physics.

Botany and physiology precisely answer the requirements of the memory stage. Chemistry, appealing to the imagination, and suffering nothing, directly, from a deficient knowledge of higher mathematics, is admirably adapted to the growth of the child during the second general division of his mental unfolding, while physics, a philosophy, comes logically and conclusively last in the science course of secondary schools.

But the advantage of proper place may be rendered nugatory by the employment of improper methods. If some of our recent text-books accurately reflect the preferences and practices of the rank and file of physics teachers, there exists today a lamentable lack of true perspective in imparting the science. The spirit of the modern exposition seems to have invaded our schools, and to have placed a premium upon "live exhibits," giving them precedence of symmetry and the logical and meritorious presentation of the subject. As an illustration in point: In seven books taken at random from a larger number prepared for high-school pupils in physics, the proportion of space in each volume devoted to magnetism and electricity ranges from twenty per cent to thirty

per cent, and the average of the seven is twenty-seven per cent, or more than one-fourth of the entire matter in the books. Surely no argument is needed to show that these texts were written without due regard for the just balancing of the subject. Indeed, the impression is of Herbartianism gone mad; principle sacrificed at the altar of interest. Doubtless electrical demonstrations quicken interest. But we need to have a care lest our class-rooms degenerate from places of education into halls of diversion and amusement. Matter and its properties, motion and its causes, characteristics and measurements, elasticity, heat, light, sound, are both jointly and severally themes of intrinsic disciplinary value. Furthermore, the unreasonable magnifying of one, or the unfair minifying of another division, is a process wholly repugnant to the very spirit of science.

I wish also to file an indictment against such schools as lose sight of proper proportion in the allotment of time to didactic and to laboratory work. A school program that provides four periods in the laboratory to one period for class-room discussion, demonstration and recitation, forces upon one the conviction that its author places novelty above utility. The high-school laboratory has its uses, and they are neither few nor unimportant. It also has its natural limitations, which may not be extended with impunity. Some of its over-zealous advocates would put it foremost as a means of teaching physics. But the conservative, saving element of the teaching force believes, and rightly, I think, that the recitation room should always precede the laboratory, and that the province of the latter is to confirm and make real the facts, laws and principles that have first been discussed in the former. It will be freely granted that a laboratory is the proper place for that research out of the fruits of which a science is built up and established; but the laboratory of a secondary school is a place of confirmation and not a place of discovery. As one, therefore, for whom the laboratory is as a mighty magnet in its attractive qualities, to whom experimentation is an enthusiastic delight, and in whom the abandonment, or undue restriction, of this branch of our work would awaken a sense of personal bereavement, I cannot refrain from expressing the conviction of impending danger that the high-school physics labora-

tory may lose its proper character as an admirable auxiliary, and, by arrogating too much, precipitate a revulsion of sentiment as unwarranted as is the present exaltation of its function by some of its injudicious friends.

Our manner of teaching physics will depend largely upon the answer which we give to the question, What should a pursuit of this study yield the pupil? I believe there is a more or less unconscious surrender by instructors to utilitarian tendencies. "What's the use?" is the almost hourly interrogation of the school-room. And more fully expressed the query would take this form: "What is there in this which you require of me today that will enable me to acquire money when I shall be through school and shall have engaged in business?" In these times, when so much is said about "practical" studies, teachers need to remember and pupils need to be reminded that practicality inheres in the person and not in the knowledge which he may possess.

Have you pondered the fact that our high-school graduates prefer the university to the college for their further education? This trend is so strong that it has been predicted by high authority that the days of the college, as an educational force in our land, are numbered. What does it signify? Is it not a phase of the commercialism so rampant everywhere? The traditions of the college commit it to breadth of knowledge,—to scholarship. The atmosphere of the university is congenial air to the specialist,—the expert. The imperious *demand* is for training rather than for education; some faculties dragged forth, and not all faculties led forth. The high school experiences the stress. Pupils are impatient. They deem a span of more than two years between the primary school and the university a waste of time. And do we not, as teachers, sometimes, in hours of retrospection, experience a twinge of regret that we have, in unguarded moments, allowed ourselves to become accomplices in this crime of commercialism against the intellectual well-being of our pupils?

Not technical training, with a view to future money getting, but a strong, broad, symmetrical mentality should be the ideal towards which all high school teaching tends. Facts, principles, laws, methods of observation, methods of thought,—these the pupils must acquire; but only as means to an end, and that end the development of balanced, orderly, effective mental power.

RECENT ADVANCES IN THE PHYSICS OF WATER.

BY GEORGE FLOWERS STRADLING, PH. D.

(Concluded from page 248.)

By Eötvös, Ramsay and Shields and others it has been found that for all normal liquids the temperature rate of change of a certain function of the surface tension, molecular weight and density of the liquid is the same and remains nearly constant almost to the critical temperature. At temperatures below 40° C. water falls in with this law, provided the density and molecular weight of trihydrol are used, instead of the numbers which hold for ordinary water. From 60° to 100° the constant which holds for other liquids is approached, if the density and molecular weight of dihydrol are used. Therefore up to 40° the surface layer of water consists of trihydrol alone. Beyond 40° the reduction of the surface tension permits dihydrol to form in greater and greater quantities as the temperature rises.

From another point of view it seems probable that the surface layer should differ in composition from the body of the water. Pressure changes trihydrol into dihydrol, and conversely the tension which exists at the surface should change dihydrol into trihydrol.

Sutherland says: "The solubility of substances in trihydrol may be different from that in water." In connection with this some recent experiments of Jan von Zawidski* are of interest. He found that foam from aqueous solutions of acetic and of hydrochloric acid containing saponin is slightly richer in the solute than the main body of the liquid, and that the same is true of saponin solution by itself to an extent which far exceeds errors of experiment.

The latent heat of fusion of ice is to be regarded as including the heat required to dissociate some trihydrol into dihydrol. This is true also of the specific heat of water. The latent heat of vaporization includes the heat of dissociation of dihydrol into hydrol. It is calculated that 189 small calories are needed to convert 1

* *Zeitschr. f. phys. Chem.* XXXV. 77.

gram of dihydrol into hydrol at 100° and 177 to change 1 gram of trihydrol into dihydrol at 0° .

The problem confronting Sutherland was this: Given a substance well known in the solid, the liquid and the gaseous states, whose behavior, especially as a liquid, is different from that of ordinary liquids in respect to a considerable number of properties, to determine what must be the relative quantities, rates of change and physical properties of two simple and normal substances by whose mixture the comportment of water shall be reproduced. Of necessity he makes his appeal in many cases to analogy, with ordinary substances, for it is one of the conditions of the problem that its solution shall be in terms of such substances. Hypothesis often confronts the reader where he could wish to find a firmer foundation, yet the longer he studies the methods employed, noting the wide acquaintance with molecular data and the skill with which they are combined, the stronger does the conviction grow that this memoir has at last shown how to explain quantitatively the anomalies of water.

G. Tamman† has found that in addition to ordinary ice, I, there are two other varieties, II and III. They differ from the common kind in these respects:

1. Their melting points are raised by the application of pressure, whereas the opposite is true of ice, I.
2. Their density is greater than that of water. This accounts for the effect of pressure on their melting point.
3. They are formed only under special conditions of pressure and temperature. Common ice is cooled below -22° C. and the pressure increased to at least 2400 kg. per sq. cm. Now if the temperature is further lowered until it is from -30° to 60 , ice III forms; if it is lowered to -80° , ice II forms.

When ice I changes into II, the following volume diminution per gram occurs:

-73°	0.171 cc.
-55°	0.180 "
-34°	0.193 "

†Drude's Ann., V., 597 (1901).

The heat of transformation of common ice into ice II or III is positive or negative according to the temperature, and is zero at about -33° for ice II, and at about -43° for ice III. The lowest temperature at which he observed water and ice to exist together was -22.4° , the pressure being 2230 kg. per sq. cm. The following table is given of the temperatures at which ordinary ice is melted at the accompanying pressures:

Temp.,	0°	1	2.5	5	7.5	10	12.5	15	20	22.1
Pressure,	1		336	615	890	1155	1410	1835	2042	2200
Kg. per sq. cm.										

It appears that the lower the temperature the less is the additional pressure requisite to produce a further lowering of the melting point by 1° .

Thiesen, Scheel and Diesselhorst* publish the following densities of water, determined at the Reichsanstalt:

0°	0.9998676	25°	0.9970715
10°	0.9997270	30°	0.9956736
15°	0.9991263	35°	0.9940576
20°	0.9982299	40°	0.9922418

In view of the long time during which the properties of water have been known and measured it is remarkable to how great an extent they still furnish a fertile field of investigation.

*Zeltschr. f. Instrumentenkunde, xx., 345.

THE STUDY OF BOTANY THIRTY-SIX YEARS AGO
WITH ASA GRAY.

BY W. J. BEAL.

Professor of Botany, Michigan Agricultural College.

It is hardly fair to compare the work of botanists and zoölogists who were active thirty-six years ago with those now in their prime. Although often stated in educational journals, it is rarely comprehended by students of today that a knowledge of these subjects has advanced more within the past fifteen to twenty years than in all former years combined.

As a resident graduate, I took my degree at Harvard in 1865. At that time there were only two persons in America earning all their living by teaching and other work in botany, and they were Asa Gray, of Harvard, and D. C. Eaton, of Yale. A considerable number of other universities and colleges gave a little botany in the course, but this was taught by persons each teaching several other subjects.

How much time was required of undergraduate students in the study of botany? At Harvard and at the University of Michigan it amounted to a grand total of six weeks of daily work on one study out of three or four pursued at the same time. I know of no college in the United States which required students to devote more than six weeks to botany, save one, and that was the Michigan Agricultural College, where very nearly a year of daily work was required. No undergraduate of the institutions named could elect any more botany than above mentioned excepting at Harvard, where three or four weeks of daily work might be spent in identifying plants with help from the teacher.

Dr. Gray assigned lessons in his larger text book and students were thoroughly questioned over the ground with an abundant supply of fresh specimens to illustrate each topic. No drawings were made on the blackboard. There were four sections of the sophomore class of about twenty-five each. The time for a lesson was one hour. Much stress was placed on morphology,—in comparing corresponding parts of different plants with each other.

I must modify my statement of the work in botany at Harvard

by saying that once during a period of six years, Dr. Gray gave a short course of illustrated lectures on geographical botany, a course not fully appreciated by most students for want of previous study. This course was elective. The botanical department of Harvard did not possess a single compound microscope, but had a costly one in its possession. The field of work at that time open to botany consisted chiefly in describing and naming and classifying dried specimens which were frequently incomplete. This is known as systematic botany, but at that time almost no account was made of the minute structure of the plant as seen with the aid of a compound microscope, nor was much attention paid to the various stages of development of the parts. The work was based on the gross anatomy of plants as seen by a hand lens. The modes of collecting and pressing herbarium specimens were crude when compared with that of our best collections of these times. The reader will note that the time of the botanist of 1865 was chiefly devoted to systematic botany, morphology and the geographical distribution of plants. These were three fields of work closely related.

Dr. Gray employed no clerk, but performed a great amount of "dead work" with his own hands. All letters were written by himself with pen and ink. He was often brief in his replies, but in many cases his letters were full of interesting points, anecdotes and plans of work to be done. His letters were social and confidential, as well as scientific. A girl mounted plants for the herbarium.

A very small number of resident graduates—one to three at a time—learned botany under the guidance of Dr. Gray. For plant anatomy we read *Mohl on the Vegetable Cell* translated; only this and nothing more, for little else was to be had that was valuable, and this work was laid on the shelf as imperfect and out of date years and years ago.

We read *Lindley's Vegetable Kingdom*, identified hundreds and hundreds of dried plants, when we couldn't get them fresh from the fields, botanic gardens or the woods. We tried our hands at original descriptions and made artificial keys. We noted all the points which characterized the families of plants. Very little time was spent on plants below the ferns and their allies.

Let us take one long step in time from 1865 to 1901, and note a few of the leading points concerning plants that are now demanding the attention of students. New worlds have been discovered and each is now well taught in many colleges. I mentioned three above. We have them still, with additions, and five at least have been added, viz.: Plant histology, plant physiology, ecology, bacteriology, parasitic fungi and saprophytic fungi. Through the rapid development of agricultural colleges and work in the United States Department of Agriculture, opportunity was offered to earn money by a knowledge of plants. The universities soon gave a greater opportunity to elect botany than ever before. Today I dare not attempt to name or enumerate the hundreds of persons in this country, all of whom get their living by work with plants. Progress in every line is most marked, as we might expect where so many well-trained enthusiasts are occupying so many different fields. Botany in any of its departments is a charming and valuable study for pleasure, information, discipline or culture.

The older botanists of today have been obliged to bestir themselves continually to keep abreast of the times. They consult each other by letter, in person, or meet in conventions. They visit a number of the best equipped laboratories of this country or of Europe and remain as students or remain long enough to secure many hints that will be of value in work with their own classes. Without this, they would soon be shelved, or teach the old botany with none of the new.

THE HIGH SCHOOL LIBRARY FOR CHEMISTRY.

J. BISHOP TINGLE, PH. D.

Professor of Chemistry, Illinois College, Jacksonville, Ill.

Most teachers will probably agree that the provision of a library for the Chemical Departments of secondary schools is almost as essential to their complete efficiency as, say, an adequate supply of test tubes and flasks; yet it undoubtedly happens that,

in too many schools, the library is either totally lacking or wholly insufficient. I desire to call attention to this need, and, if possible, strengthen any efforts to meet it, because experience has shown me that the possession of a library will be speedily attended by beneficial results, both to the teachers themselves and to their students.

For several years it has been my privilege to interview students, with some chemistry credits, coming from other institutions, and to the question, "What work have you done on the subject?" I have frequently been told, "Oh! I have done a *great deal* of chemistry. I have had *a year of it*"; or, "I have done the *whole* of chemistry; we studied it *two hours weekly during six months*." The italics are the student's. Obviously an individual entertaining such quaint ideas must first have impressed on him certain of the more elementary truths of perspective, and be brought to a truer realization of the actual relationship of his ego to the cosmos. The operation is usually rather painful to the student, somewhat of a bore to the teacher, and involves an expenditure of time that might be better employed.

Again, it is frequently found that an inaccurate statement or definition is regarded as beyond question "because So-and-so says it," So-and-so being the author of the text-book in use. The ideal text-book remains to be written, few of the available ones are without error, all have some blemish, and it appears that the teachers' efforts to correct them often had the effect of impressing the inaccuracies on the mind of the student with special force. A well-selected library materially helps towards the elimination of both these troubles; its use broadens the student's outlook as to the extent of the subject, and enables him to collate various accounts of any part of it. This often has the further great advantage of enabling him to grasp some special point, as put by B, that he may have vainly struggled with in A's book. In addition it begets in him the habit of reference, which must be of considerable value in subsequent work, and reading somewhat away from the routine lines will open up new paths of interest and extend old ones.

The chief advantages to the teacher of a library are perhaps two: access to reliable books of reference, and means of keeping

abreast of new work, including not merely the results of research as usually understood, but also improvements in lecture and class experiments, novel equipment, etc. Should the teacher be compelled to purchase his own works of reference, a somewhat heavy and rather inequitable tax is imposed on salaries usually far from liberal.

As regards the second point, many teachers are from their location necessarily deprived of ready access to current technical periodicals and books, and even if the works are available, the large amount of time required merely to "skim" them is a serious matter, whilst the rapid advancement of knowledge and the resulting luxuriant development of novel terminology, renders it difficult for any but specialists in various branches of the science to recognize the relative importance of new work and assess it at its approximate value.

THE STUDY OF BACTERIA IN THE PUBLIC SCHOOLS.

BY JAMES E. PEABODY.

Instructor in Biology, Peter Cooper High School, N. Y.

The highest aims in "municipal housekeeping" can never be attained by Boards of Health or by Departments of Street Cleaning alone, however efficient these organizations may be. Unless these city departments are backed by a strong, intelligent public sentiment we shall experience nothing better than sporadic reform in the cleaning of our streets, in the construction of tenement houses, and in the general care for the public health. When conditions get sufficiently bad in a community, it is comparatively easy to arouse the voters and roll in a reform administration by big majorities. But alas! we soon tire of our attempts at public virtue, we reverse our votes at the next election, and sink back into easy toleration of filth and its resulting disease. One might indeed become pessimistic with reference to the future of our cities were it not true that democracy possesses a most powerful means of developing a public sentiment which may be at once intelligent and lasting. Gathered in our schools of today are the

boys and girls who will be the voters and the home-makers of tomorrow. Hence to the teacher, especially in the public schools, is given the opportunity to exert a telling influence in developing the better city of the future.

The discoveries in bacteriology within a few years have made new sciences of surgery, medicine and sanitation. Epidemics of typhoid fever have ceased to be regarded as "a dispensation of an all-wise Providence," for we have come to know that the presence of this disease usually means a contaminated water supply or imperfect sewerage. Scientific men have learned, too, how to check the ravages of yellow fever and cholera, and even consumption is found to be a preventable disease. To make these discoveries of practical use, however, this knowledge must be possessed by a large majority of the citizens in a community, and the most effective means of attaining this end is by educating the pupils in our public schools. With this object in view, in the Peter Cooper High School, New York City, we devote considerable time in the course in biology to the study of bacteria, yeast, and moulds.

In this study, it is necessary at the very first to impress the pupil with some idea of the omnipresence of these micro-organisms in everyday life; and for this purpose an experiment performed by the boy or the girl is always more telling than a talk by the teacher or a dozen pages of description. We begin with the study of a hay infusion. The work is done by each pupil at home, and the report presented at the next recitation. The following account is selected from the one hundred and fifty papers received from the first year pupils:

Straw Infusion. I procured about a handful of straw at a livery stable and put it in a Mason jar three-quarters full of water, and put it in a warm place where the temperature was on an average of 75° , on Thursday, March 22. Its color was tan and the mixture smelt like musty straw.

The 23d, temperature 73° , mixture getting darker in color, and smell becoming more noticeable. Saturday, temperature 74° . A thin scum is forming and small things are coming up from the bottom and straw. The smell is getting very strong.

Sunday, temperature 74° , scum becoming thicker and bubbles appearing in it.

Discussion and microscopical examination in the class room

brought out the fact that the scum was composed of countless bacteria and other micro-organisms which had grown from the germs on the dried hay. The inference was drawn from the experiment that bacteria grow rapidly in a warm temperature, when water and organic matter are present, and that decay is one of the results of their activity.

The cultivation of bacteria in the laboratory was the topic next considered. Nutrient gelatin, the most useful medium in which to grow all kinds of bacteria, may be readily prepared in the laboratory or in the home kitchen. The ingredients necessary are the following: one pound of lean beef chopped fine (or better run through a meat cutter); 60 grams (2 oz.) of the best French gelatin; 6 grams (1-5 oz.) of peptone, which can be bought for 10 cents at any drug store; a teaspoonful of salt, and a little baking soda. Put the beef in a porcelain or agate dish, add a pint of cold water, and allow the mixture to boil slowly for a half hour. Strain the broth through muslin and then allow the liquid to run through filter paper. Pour in enough water to make the quantity of broth equal to about a pint and a half.* The gelatin, cut into small pieces, is then added to the broth, together with the peptone and salt. The mixture should be heated sufficiently to cause the gelatin to dissolve, but should not be allowed to boil. Just enough cooking soda is added to cause red litmus paper dipped in the mixture to turn blue, that is, the liquid should be faintly alkaline. Filtering the hot gelatin sometimes involves more or less difficulty. The process can be easily carried on, however, with a steam cooker. A glass funnel should be put in the mouth of a Florence flask (used commonly in a chemical laboratory) and one or two layers of absorbent cotton placed within the funnel. If the gelatin, flask, and funnel are kept hot within the cooker the liquid will readily pass through the cotton. After filtering, close the mouth of the flask with a plug of absorbent cotton, and boil for a few moments. The flask may be set aside as stock gelatin until needed for use. (If the gelatin mixture is not clear, it should be filtered through the same cotton a second time.)

Some of the liquid gelatin was poured into clean Petri dishes,

* This broth may be prepared more easily from Liebig's beef extract. Four grams should be dissolved in a pint and a half (750 cc.) of water, and the solution filtered.

or test tubes plugged with cotton may be used. After the gelatin had solidified some of the dishes were opened to the air. Several days after this exposure the cultures were placed upon the desks of the pupils, and they were asked to make drawings of the bacteria colonies, and to answer certain questions stated in the Laboratory Manual.*

One of the boys, not satisfied with the amount of laboratory work given in school, prepared nutrient gelatin at home. He writes thus of his experiences:

I took about a half pound of lean beef and after cutting into pieces placed it in a pot and covered with water, then brought to a boil. I should also mention that I used a moderate fire so that the process occupied about twenty minutes. After obtaining my broth I added gelatin and brought again to a boil. Here I added some salt and carbonate of soda, after which I strained the broth through cotton into a sterilized bottle and corked.

I experienced such trouble in clearing the gelatin of colonies that I finally melted the gelatin and poured it into test tubes and in them brought it to a boil with the result of one tube burnt and five cleared. In three of the tubes Mr. Peabody inoculated pure cultures; one of the tubes has produced a very large red colony, the others have not grown.

This laboratory work on the growth of bacteria was followed by an experiment performed at home by the pupils. One of the girls gives the following report of her work:

The Study of Bacteria in Milk. I procured three bottles of about the same size. I then thoroughly cleansed each bottle before I used it. Two of the bottles had stoppers; the other had none. One of the bottles I half filled with good fresh milk, put the stopper on, and set it outside the window. I labeled this bottle "No. 1."

Into the second bottle I poured about the same amount of milk, and set it aside in a warm temperature of about 70°. I labeled it "No. 2."

The third bottle I cleaned in very hot water. I then boiled the same amount of milk that I put in each of the other bottles. I allowed it to boil for about three minutes. After the milk had cooled a little I poured it into the third bottle. I placed it beside bottle No. 2, and labeled it "Sterilized Milk."

At the end of fifteen hours I examined each of the bottles. I

*Laboratory Exercises in Anatomy and Physiology.—Henry Holt & Co., 20 W. 23d St., N. Y. City.

noticed that No. 1 had very little smell at all. No. 2 had a sour like smell. It smelled as if the milk were turning. No. 3 had hardly any smell at all. If there was any smell at all, it was a sweet one. I now boiled the milk in No. 3 again. I first thoroughly cleansed the bottle and cork before I put the milk in. I then placed it beside No. 2, and put No. 1 again outside the window.

At the end of twenty-four hours I again examined my bottles. I found that No. 1 had not any smell at all. No. 2 had a very decidedly sour smell, and No. 3 had a sweet smell.

The changes in the milk are due to the growth of the bacteria from the air, or on the bottles, or the stoppers. As far as my experiment has worked I do not think a cold temperature kills the bacteria, but I think it numbs them. I think a boiling temperature kills the bacteria, and I think a moderate temperature increases the growth of the bacteria.

Successful microscopical work was done with magnifying powers of about 500 diameters. Pure cultures of spherical-, rod-, and spiral-shaped bacteria growing in test tubes of gelatin were supplied us by Dr. T. Mitchell Prudden of the College of Physicians and Surgeons, to whom I am much indebted for help in this bacteriological work. Microscopical slides are easily prepared thus: Hold upside down the test tube in which bacteria are growing, and carefully remove the cotton from the mouth. Touch one of the colonies of bacteria with the point of a needle, and then rub the needle point on a clean glass slide; add a drop of water to the spot touched by the needle, cover with a cover-glass. Stains (Loeffler's methylen blue and Ziehl's carbol fuchsin) bring out more clearly the structure of the bacteria. Each of the thirty-five pupils in a division examined the stained bacteria, and watched under another microscope the motion of the living forms. One pupil's written account of this study is here given:

Microscopic Study of Bacteria. 1. The bacteria which I saw under the microscope last Wednesday were of red and blue colors. This was caused by the coloring matter (stains).

2. They were of three different shapes, round, pencil-shaped, and corkscrew.

3. The bacteria which I saw to-day under the microscope are moving around.

4. There were also under the microscope egg-shaped animals which were moving around. (This slide was prepared from the hay infusion and contained infusoria.)

A little mathematical problem worked out by each student helped to make real the rapidity of multiplication among these micro-organisms. The pupils were told that a rod-shaped bacterium, when conditions are favorable, divides in about an hour to form two bacteria. The problem was stated something like this: Suppose we start with a single bacterium this morning at 10 o'clock; if conditions are favorable, how many cells could be seen at 11 o'clock? The answer was "two." Between 11 and 12 o'clock each of the two would divide to form two; hence at 12 o'clock it was evident that there would be four bacteria in place of the single cell at 10 o'clock. The pupils, continuing the calculation, found that if the process were to go on until 10 o'clock the next morning, the original bacterium would give rise to 16,776,216. The completion of this calculation for a second day's crop of bacteria was not attempted for obvious reasons.

Thus far the experiments and discussions had made real to the pupils the existence of countless millions of micro-organisms. They had learned something of the form, size, and motions of the individual bacteria; and they had become acquainted with some of the results of their activity in causing decay, in souring milk, and in producing colors.

Some of the conditions which tend to check the growth of bacteria were learned from the milk experiment performed at home. A laboratory demonstration developed this subject still further. One of the boys described the experiment thus:

Sterilization. Mr. Peabody took three test tubes and inoculated some of the bacteria from the hay infusion. The first test tube contained nourishment in a solid form (nutrient gelatin), and after the bacteria had been inoculated it was set aside. The second test tube was prepared the same way, but Mr. Peabody poured some corrosive sublimate over the surface of the gelatin. The third test tube was prepared in the same way as the first, but was put in the (steam) sterilizer for five minutes, and then set aside.

At the end of five days we examined the tubes and found that the two tubes, one sterilized by heat and the other by poison, were perfectly clean, while the other had a large colony growing. From this I infer that corrosive sublimate and the heat killed the bacteria.

We are fortunate in possessing a hundred copies of "The Story

of Bacteria"* and a like number of "Dust and its Dangers"* by Dr. T. M. Prudden. These books were loaned to the 192 pupils who were studying the subject, and about one-fourth of the chapters were assigned for text-book lessons. One may judge of the interest in this study by the following figures: When the books were returned it was found that 103 pupils had read the whole book; that the books had been read by 197 parents or friends of the pupils; and that various topics in bacteriology had been discussed in over half of the homes.

(To be continued.)

GAS GENERATOR.

BY GEORGE A. COWEN.

Instructor in Chemistry, West Roxbury High School, Jamaica Plain, Mass.

A convenient and useful generator can be made as follows: Two bottles of equal size are fitted with tubes and stoppers as shown in Fig. 1. Bottle A contains the solid,—zinc, marble, or

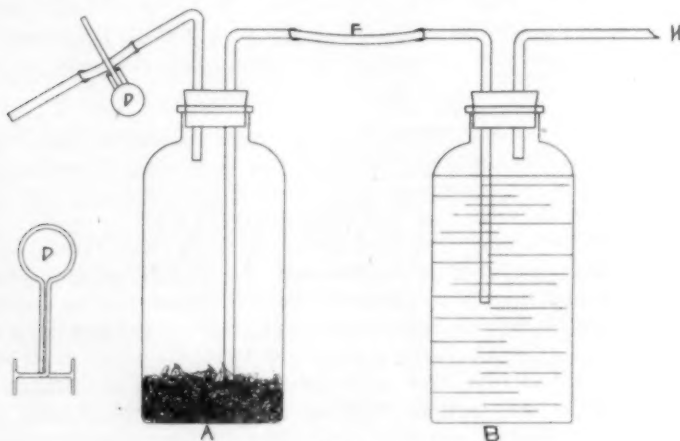


Fig. 1.

*Published by G. P. Putnam's Sons, W. 23d St., N. Y. City.

sulphide of iron; B contains the dilute acid. To start the reaction, open stop cock D and blow gently through H. The acid siphons over through F until its end is exposed. It is necessary to have this tube short, that the siphon may empty and cause a slight back pressure. When considerable pressure is required a stopper must be placed on H. When the stop cock is closed, the liquid returns to B and action ceases.

It will be noticed that the upper and better part of the acid is always used.

While gas is being delivered, B can be disconnected at F and the spent acid thrown away.

A generator of this form can be made for 25 cents. The bottles can be put in a block for convenience in handling.

A DISCUSSION OF NEWTON'S THIRD LAW OF MOTION.

BY E. E. BURNS.

Instructor in Physics and Chemistry, DeKalb (Ill.) High School.

The thoughtful pupil, who is studying the laws of motion for the first time, is sure to find difficulty in reconciling Newton's third law with the principle of balanced forces. The meaning of this law is that every force is accompanied by an equal force in the opposite direction. Before reaching this point, the pupil has been taught that, if two equal forces act in opposite directions upon the same mass, no motion results. If these two statements are the whole truth, motion is an impossibility.

A simple illustration makes the matter clear. I have used the following in my class room and I have good reason to believe that the result has been a clear conception by a majority of my pupils of the meanings of these two laws and the relations existing between them: I hold in my hand a spring balance from which is suspended a mass of, say, five pounds. The force due to gravitation is five pounds and is acting upon the mass in a downward direction. The hand is exerting an equal force in an upward direction and there is no motion. These points and

those that follow are, of course, brought out by questioning. To move the mass upward, the upward acting force must be increased. I do this and, for an instant, the index of the balance indicates eight pounds. The total force exerted by the hand upon the mass at the instant of setting it in motion is eight pounds. That the mass is affected by an equal force in a downward direction, we know, since it stretched the spring as much as an eight-pound weight would do. The added downward force of three pounds is due to the inertia of the mass (and this makes the meaning of inertia more clear). We have, then, two equal forces acting in opposite directions upon the same mass and the mass is set in motion. This is true because one of those equal forces consists in part of the force due to inertia. We must, therefore, recognize a force of inertia and we may include Newton's third law and the principle of balanced forces in one comprehensive statement thus: Every force is accompanied by an equal opposing force. The effect of such equal opposing forces is rest, except one of the forces consist in whole or in part of the force of inertia, in which case the effect is motion.

EXPERIMENTS WITH THE SCHOOL ELECTRICAL MACHINE.

BY OLIVER P. WATTS.

Instructor in Physics, Waltham (Mass.) High School.

For two years past, whenever time has permitted, I have been conducting a series of experiments which are of the greatest interest to me, and which I believe will prove of equal interest to most science teachers. As the necessary apparatus ought to be, and probably is, to be found in every high school, I call the attention of high school teachers to them. The experiments are a study of the forms of high potential electricity as recorded by its direct action on the photographic plate.

The first success in producing a visible record of electrical forms seems to have been achieved by Lichtenberg, in the last quarter of the eighteenth century, by dusting sulphur, red lead,

etc., upon a non-conducting plate which had been touched with the knob of a charged Leyden jar. The first electrical record upon a photographic plate was undoubtedly a photograph of lightning. Who first tried the direct action of electricity upon the photographic plate, I do not know, but it had been done in England at least as early as 1892. My first knowledge of it came from an exhibit of such pictures in connection with a powerful induction coil, at the Mechanics' Fair in Boston, in the fall of 1898. In answer to my inquiries of the man in charge of the exhibit, I could only learn that the pictures were made with the coil without using a camera. In January, 1899, I commenced experiments with the school static machine, though with small hope of success, as the longest spark that I could obtain was one and a half inches, instead of the sixteen to twenty-two inch spark of the coils exhibited. I worked at night by a ruby lantern, holding the film side of the photographic plate against the poles of the electric machine, and developing the plates as usual after exposure. I quickly discovered that the film was a somewhat better conductor than air, and so sparks could be obtained across the plate more than twice the maximum sparking distance in air.

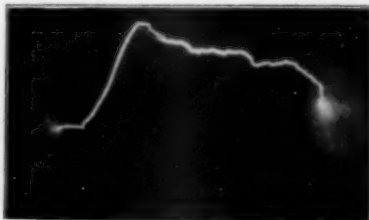


Fig. 1.

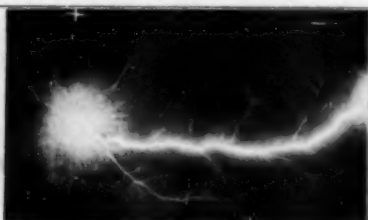


Fig. 2.

Fig. 1 (size of original $3\frac{1}{4} \times 4\frac{1}{4}$ inches) shows one of the earliest, if not the first picture that I made. Surrounding the two poles are faint streamers, which even here are seen to be unlike in form. I soon found that by the inductive action of a strip of tin-foil on the glass side of the plate, the length of spark was considerably increased, as was also the spread and intensity of the action outside the spark itself, as seen in Fig. 2. Fig. 3 shows

the blue, scarcely luminous, streaming discharge obtained when the Leyden jars of the machine are disconnected. The general tendency of the radial streamers from the positive pole is to avoid each other, and to branch indefinitely. On the side toward the negative pole this tendency is disturbed, and a discharge takes place, not only from those streamers which start directly towards the negative pole, but from others which curve around, when they reach a point somewhat remote from the positive pole, and join themselves to streamers going to the negative pole more directly than themselves. At the junction there is a spot of in-

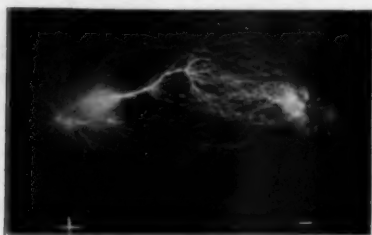


Fig. 3.

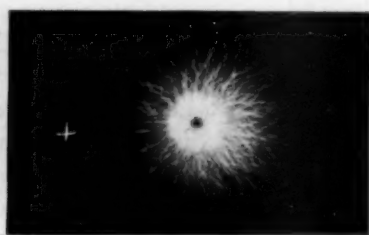


Fig. 4.

creased action on the plate. The whole figure shows the superior spreading and reaching out of the positive electricity. Fig. 4, which might well represent a dandelion or some similar flower gone to seed, was made by holding a plate perpendicularly between the poles, and is a record of positive electricity.

Fig. 5 (original 8x10 inches) shows well the branching dendritic form characteristic of positive electricity, and the feather-like character of the negative. This is one of a dozen pictures made at Harvard University, through the kindness of Professor Hall. The machine with which it was made gives a five-inch spark. To form these perfect figures, it is necessary to set each kind of electricity free from the attraction of that at the opposite pole, which otherwise would cause a spark discharge to take place. This is done by placing a sheet of tin-foil, or any other conductor, beneath the plate, when by induction the opposite electricity is developed everywhere beneath the branches on the film side, and because of its nearness, "binds" the charge on the film. Under these conditions, positive and

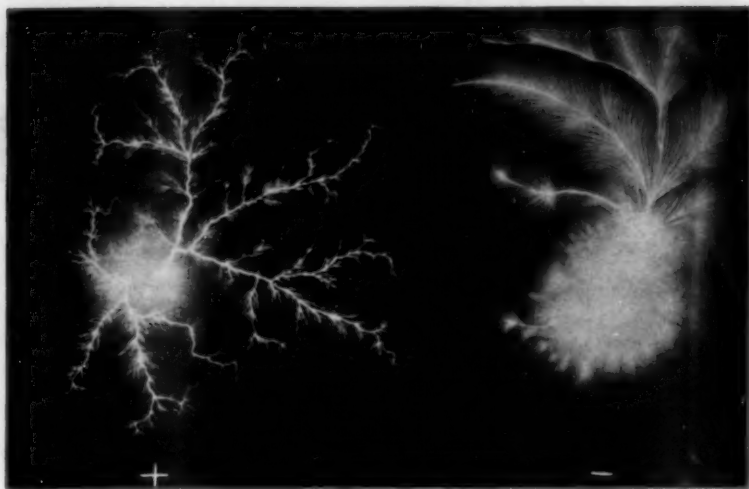


Fig. 5.

negative may approach within one-half inch of each other without any sparks passing, and so they may develop freely over a great extent of surface, each according to the force or forces within itself. Such a plate is heavily charged with electricity and is, in principle, a Leyden jar, except that because the film is a poor conductor, by touching the two surfaces, the discharge is only in the vicinity of the part touched on the film side.

These are a few out of many interesting forms. While I do not feel that I have discovered as yet any facts about electricity which are of great scientific importance, yet I have learned many things which to me are very interesting, and I am sure that there is more to be learned by further experiment. If a plate be charged by holding it between the poles of the machine, taking care that a spark does not pass over the edge of the plate, in the finished picture broad bands of light will be seen following in a general way the course of the main branches on the film side of the plate, though not coinciding exactly. These are sparks which went out from the opposite pole to charge the plate on the glass side. I am convinced, that for any electrical disturbance on one surface of a plate, there is always one of an opposite



A BEAUTIFUL NEGATIVE CHARGE

nature on the other side. This is only a visible illustration of the old story that the two "kinds" of electricity are always associated in any electrical disturbance, never one alone. Other observations cannot be even mentioned in this article for lack of space. Many questions arise: Is this action on the photographic plate due solely to the light of the electric spark, so that these pictures may properly be called photographs, or is it an effect produced by the electric current? Is lightning only similar sparks on a grander scale, having such minute tributaries and veinings accompanying all its ramifications, or does the camera reveal all that there is to the lightning flash? I find seeming corroborations of each view. The whole subject is a most fascinating one to a

person who has any fondness for experiment, and the beauty of the results will well repay the time and expense of securing them. The teacher of physics will find these pictures a help in showing pupils by visible, indisputable evidence, that the terms positive and negative stand for a real difference in electrical conditions, and are not mere names coined to bolster up a doubtful theory.

Instead of a static machine, a coil of similar power may be used. A one and a half inch spark will produce figures covering a four by five plate; a two-inch spark will cover a five by seven, and a five-inch spark will cover an eight by ten plate very well. By wrapping the plates in black paper, a little light may be admitted to the operating room, though it should be remembered that the spark pierces the paper. In this case, quite an alteration is produced in the form of the negative figures, and they somewhat resemble the positive in form. (Any information on the literature of the subject, or photographic prints of lightning resembling these figures will be appreciated by the writer.)

ELEMENTARY EXPERIMENTS
IN
OBSERVATIONAL ASTRONOMY.

BY GEORGE W. MYERS.

(Continued from page 263.)

EXPERIMENT VIII.

To map with a plane table and home-made stadia the form and outline of a field, or pond, and locate any permanent objects within it.

Construction of apparatus.

From surfaced inch-stuff, cut two pieces according to the dimensions given in the drawing. To one attach two strips of tin or brass, or card-board, as shown at C, and to the other fix two

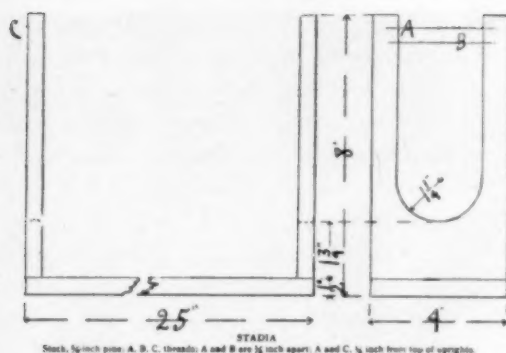


Fig. 11.

parallel black threads $\frac{1}{4}$ inch apart as shown at A and B. From the same stuff cut, square, and surface a board 25 inches long, and nail the former two pieces to the latter.

By looking through the back slit between the strips at C, first toward the upper thread, A, and then at the lower one, lines of sight may be directed toward a remote object at such an angle with each other that the distance of the object sighted will be 100 times as great as the length of the part of the object included between these lines of sight. Measuring the space, therefore, the distance of the object becomes at once known, and *vice versa*.

Place the plane table (Fig. 7) over some commanding point on or near the tract to be plotted, and, if the tract is level, bring the board into a horizontal position with the aid of a spirit level, such as is suggested under Experiment V (b). In other cases tip the board by shifting the tripod legs until it is roughly parallel to the surface of the tract to be mapped. With thumb-tacks attach a piece of paper to the board, and, sticking a pin at some convenient point, sight the alidade, held against the pin, to flag-poles placed at salient points (corners, or sharp turns) drawing lines with a sharp pencil along the edge of the alidade in its various positions.

Removing the alidade and placing the stadia upon the table, with its edge parallel to the successive lines, an assistant will note and record the length of the space intercepted on the

flagpole at each point about the perimeter, and at any objects on the tract to be plotted, between the two lines of sight, one passing from the eye-hole (C) over thread A, and the other from C over thread B. If the instrument has been constructed in accordance with the specified dimensions, the distances from the table to the various poles will be 100 times the intercepted spaces on the poles. Why?

These distances may now be laid off from the pin on the lines drawn with the alidade to any desired scale, and a line drawn through the perimetral points will give the outline and form desired. Objects will be located in their proper relative places by plotting the corresponding distances on the lines from the pin toward the respective objects, the same scale being used.

PROBLEM: Map and locate from any convenient point the form and objects of your playground, or other tract of ground being studied.

EXPERIMENT IX.

To find the diameter (roughly) of the moon or sun.

(a.) Holding a graduated lead pencil at arm's length, place the thumb so that when the end of the pencil is in line with one crescent tip the thumb will be in line with the other tip. Note the distance from the thumb to the end of the lead pencil. Assuming the distance to the moon to be 239,000 miles, what is the moon's diameter?

[REMARK: The value of this method of executing the experiment is in showing on what the solution of the problem of finding the lunar diameter depends.]

(b.) The experiment may be performed more accurately with a stick placed at some twenty feet from the eye, the distance between the points on the stick where the lines of sight to the two crescent tips pass it being measured.

(c.) A movable sight carried along a scale fixed perpendicularly to a stick or rod some twenty feet long will give a still more accurate solution.

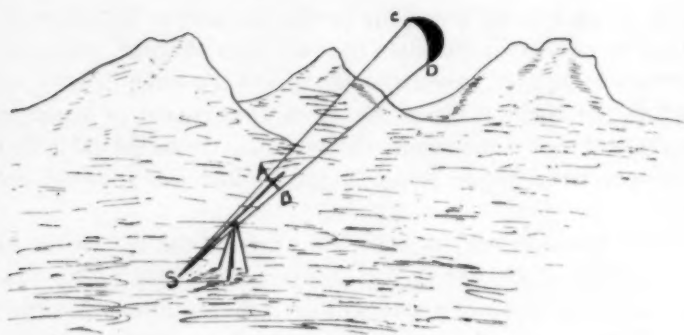


Fig. 12.

(d.) These measured values may be checked by the aid of Ephemeris' data, or with Sextant measures. (A cheap wooden sextant can be bought of the Chicago Laboratory Supply and Scale Company).

(e.) These same experiments may be carried out for the sun by shielding the eyes with a pair of colored spectacles, or with the aid of smoked glass. When the moon is very bright, slightly shaded spectacles will make better settings on the lunar limb possible. See also Fig. 13 for a convenient form of apparatus for this experiment.

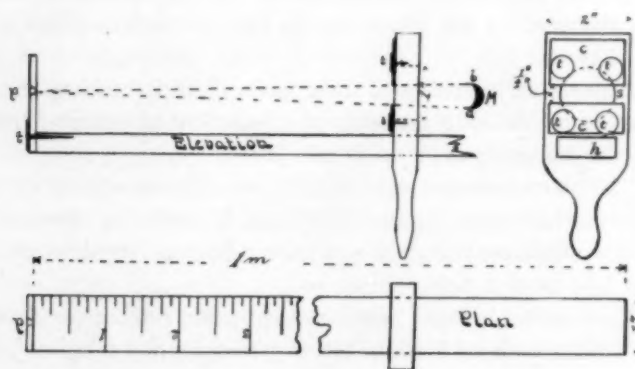


Fig. 13.

EXPERIMENT X.

To determine the form of the moon's orbit.

Using an apparatus similar to the one figured here, a good idea of the principles involved in determining the form of the moon's orbit may be obtained.

The apparatus consists of a yard or meter stick, at one end of which a thin strip of wood, or card-board, is pinned with a thumb-tack. This strip is perforated at P with a pin-hole through which the sights are to be taken. A paddle-shaped carriage, supplied with an oblong hole, h, of such form and size as to slide with gentle friction along the meter stick, is perforated with an inch-hole, the center of which is about as high above the upper surface of the meter stick as is the pin-hole. Across this hole two card-board strips are pinned, with thumb-tacks, with edges parallel and a quarter of an inch apart. The advantage of using the yard, or meter stick, is that a self-graduated measuring bar is thus secured. Indicated dimensions are intended only as suggestions.

The measures are taken by looking through p and tipping the apparatus until the line of the crescent tips of the moon stands perpendicularly across the slit, S, at the same time sliding the carriage back and forth along the bar until the tips of the crescent simultaneously just touch the respective edges of the slit. The distance from p to t is then read off, and is the observational datum furnished by the instrument.

REDUCTION AND INTERPRETATION OF OBSERVATIONS.

Tie the ends of a cord some forty or more feet long, one to a stake stuck in the ground at a point as F₁, and the other at F₂, at a distance of some 25 feet from F₁. Catching the cord at some intermediate point, say C, draw the cord aside until the ends CF₁ and CF₂ are equally taut and then stick a peg at C. In a similar way stick pegs at D, E, . . . A. Placing a globe of (say) one inch in diameter at A, and standing with the apparatus at F₁, slide the paddle to and from the eye until the edges of the globe are tangent to the edges of the slit, S of Fig. 13. Read the distance to t, the setting of the paddle, and record it. Also measure the distance NF₁, on the ground and record it in a

column beside the setting of the carriage. Move the globe to C, and record the two data for this point in the same way. Proceed similarly for some eight or ten points on the ground. By examining the two columns of data can you discover any law connecting them?

ANSWER: They are proportional.

Hence, if we should draw on a sheet of paper by aid of the apparatus of Figure 7 a number of lines from a given point, directed toward the points A, C, D, E, . . . A and then lay off on these lines the values of the readings furnished by the carriage settings, by drawing through the points on the paper thus located, a continuous curve, we should get a curve of the same shape as the continuous curve drawn through all the points on the ground. That is, we could infer from the curve on the paper *the form of the curve on the ground*. Note that this inference is based entirely on the readings of the instrument.

Laying off on a system of radiating lines, the carriage settings for the moon from day to day, or from week to week, we might then in this way infer the form of the moon's path from the curve we draw through the points located on the paper by the instrument settings, *if we could draw the radiating lines so as to make them include between them the proper angles*. These angles may be obtained with sufficient approximation for this purpose by taking the difference of the longitudes of the moon for the dates of observation from the *American Ephemeris*.

They may also be obtained observationally by the aid of the cross staff by measuring the angular distance of the moon from a star just ahead of, or behind, the moon, for two, or three, consecutive times and subtracting, or by triangulating with the cross-staff the distances from the two stars along the moon's path, locating the stars by their right ascensions and declinations on a globe, indicating with a pair of dividers by two intersecting arcs the positions of the moon for the dates and scaling off the number of degrees between the successive positions. See under cross-bar, Fig. 15, Experiment XII.

When the form of the moon's path has been thus drawn, if any one of these distances be obtained from the *American Ephemeris*, the scale of the drawing will become known, and the dis-

tances corresponding to all of the dates of observation are readily deducible.

Carry out the measures on the moon for intervals of two or three days throughout some entire month.

(To be continued.)

Metrology.*

THE CENTENARY OF THE METRIC SYSTEM.

BY JACQUES BOYER, in *Revue Encyclopedique Larousse*.

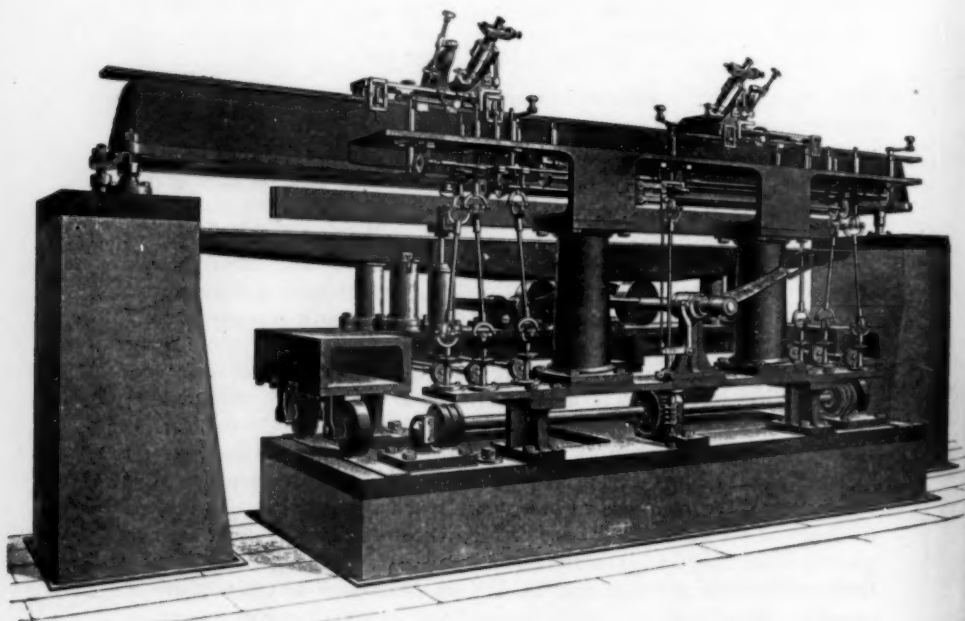
Translated by DR. WILLIAM H. SEAMAN.

(Concluded from page 212)

These instruments differ slightly from each other according to particular work for which they are intended. The first, made by Brunner, is adapted for line measures, that is to say, scales in which the length is determined between two lines, one drawn on each end of the scale. The microscopes, solidly fastened to the heavy masonry, carry micrometers such as are commonly used on optical instruments, and furnished with spider threads moved by micrometer screws. These threads are made to coincide with the lines of the scale by turning the screws a certain number of divisions, and knowing the distance corresponding to each division of the screw head, it is easy to determine the distance between the lines on the scale. The body of the comparator is an enormous casting whose top is a kind of railway over which rolls a heavy carriage moved at will by gears controlled by a handle. On this carriage rests a double walled box of metal in which are placed the two scales to be compared. The mechanism allows the operator to move the whole box in any direction so as to bring each extremity in focus. In this way the lines on the ends of each are carefully compared, and besides the comparator is furnished with thermometers provided with magnifiers by which their movements are seen and all sudden variations of temperature are

*Communications for the Department of Metrology should be sent to Rufus P. Williams, Cambridge, Mass.

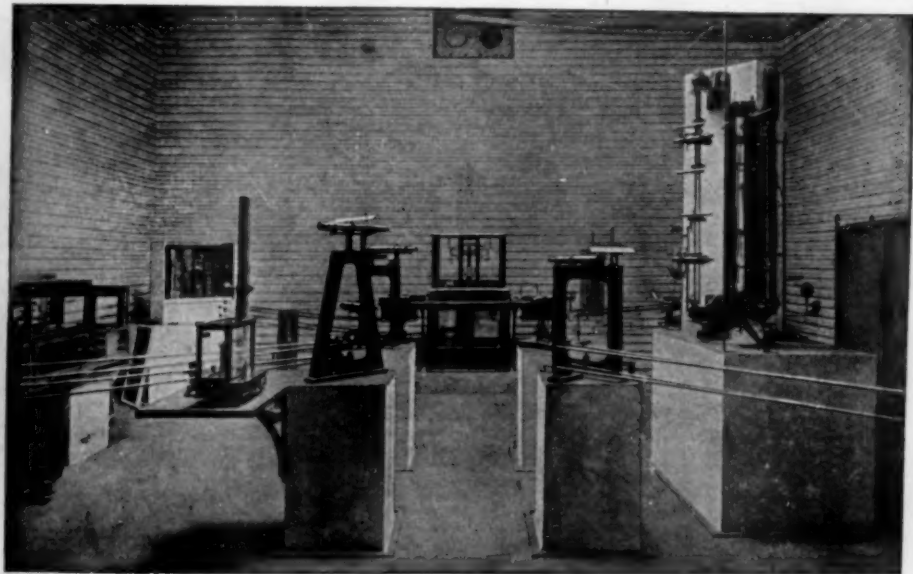
carefully avoided. The second comparator is for the purpose of studying the expansion of metric scales. It differs from the preceding in that the carriage has two boxes separated from each other, in each of which a scale may be placed and subjected to different temperatures. The standard one is kept at a fixed temperature, while the other is heated or cooled. Thus its contraction or expansion is measured by reference to the standard near it. We need not speak of the difficulty of maintaining a constant temperature, but we may say that the arrangements at Breteuil enable a liquid bath to be kept for hours at a temperature varying only by a few hundredths of a degree. These two instruments enable us to determine the relative length of two scales within a few microns, while with the third comparator, called the universal, lengths up to two meters may be examined. This instrument differs in several particulars from the others, its microscopes are not fixed, but are borne by two carriages that roll on a sort of bridge extending between two pillars of masonry. This bridge is a heavy casting that has steel ways on its upper side made perfectly horizontal, which guide the movement of the microscopes. When placed in the proper position these are fixed by a set screw. Underneath is a carriage for the measure to be examined, capable of motion in every



The Universal Comparator of the International Bureau of Weights and Measures.

direction on a horizontal plane. The instrument has a scale divided into centimeters, and was made by Starke and Kammerer of Vienna, and does great honor to that establishment. It is shown in our illustration without the mahogany box which encloses it. It has many uses, the comparison of end measures, the determination of dimensions other than those of the metric system, the determination of subdivisions of the meter, especially of the millimeter, which is so necessary to fix the degree of precision observers may expect from micrometric instruments employed in delicate experiments. The last instrument is the geodesic comparator, which is a combination of five comparators. As its name indicates, it serves for the study of the large rods, four meters in length, used in the measurement of base lines in geodesy. This work is very difficult. It is done by the help of electricity, but its construction is too specialized to render a description desirable here, and we pass to the other apparatus of the pavilion of Breteuil, viz., that intended for the examination of weights.

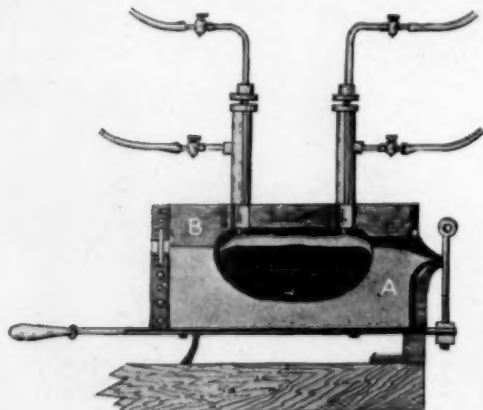
The weighings at the International Bureau are made with balances of great precision in a room especially designed for this purpose. Those which are used for the determination of the kilogram are so arranged that they may be manipulated at a distance. On the evening of the preceding day,



The Balance room of the International Bureau of Weights and Measures.

the observer places in the case of the balance to be used the weights that are to be employed, since he may not again come near it for fear of changes in temperature his presence would cause. Twenty-four hours after he performs the weighing at a distance of at least four meters by means of the long lever arms shown in our illustration. That is to say, the balance is provided with ingenious mechanism by which the weights may be placed, changed from one scale to another, the balance liberated, etc., etc., from a distance. The oscillations of the index are observed by a telescope fixed by metal to one of the pillars that support the various levers. A mirror is attached to the index of the balance which reflects a divided scale of which the image is seen by the observer to move in the glass when the balance oscillates. The extreme positions, or ends of the swing, are noted and the mean taken for the position of equilibrium. The delicacy of these instruments is such as to admit of detecting a difference of one-hundredth of a milligram between two kilograms. It would require too much space to speak of the other balances, or to describe the apparatus used to measure temperature, which measurement is very important in determining standards of length or of weight.

Having now described the principal instruments of the International Bureau, let us return to a history of the more important researches that have been executed since 1878, for the purpose of establishing a new international meter.



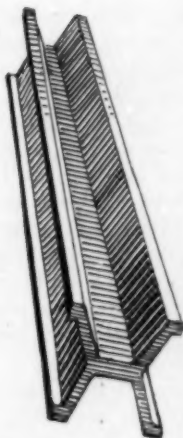
Oxyhydrogen furnace used for melting platinum. A, crucible. B, crucible cover.

C, handle to raise the crucible and pour the melted platinum.

R R, supply tubes for oxygen and hydrogen.



Case for one of the Prototype Copies of the Meter.



Form of the new Standard Meters.

The meter of the Archives is made of a flat bar of platinum, forged by Janetti from platinum sponge. The extremities are rounded, and the distance between the middle of the two end faces, measured at zero, defined the meter of 1799. This form has been abandoned by modern metrologists because they have recognized certain advantages possessed by strong lines drawn on the plane of the neutral axis of a bar. This plane contains the center of gravity of the bar, and its length is independent of the mode of suspension. The material is an alloy containing 90 per cent of platinum and 10 per cent of iridium. Many analyses were required before the proper mixture was obtained, and three years of labor were spent before the ingot was cast. As the metal cost 3,000 francs per kilogram, an X form was chosen for the sake of economy, and also because the maximum of rigidity was thus obtained with the minimum of weight.

The international prototype meter was obtained in the following manner: First, a provisional standard was made as near as possible the same length as the meter of the Archives. By many measurements it was proved to be six microns longer.

This work was done in 1881-2 by a commission composed of MM. Broch, Forster and Stas, members of the International Committee, and Dumas, Tresca and Cornu, of the French section. The latter then took charge of perfecting the standards, while the others attended solely to their verification. When the length of the provisional standard was determined, it was used to prepare forty prototypes. These various scales were compared among themselves and it was shown no one of them differed more than three microns from the meter of the Archives.

That which was the nearest in length was called the International Meter and was afterward denoted by a German capital M in all diplomatic and scientific documents. All the standards were then compared for the last time. Most of the work was done by M. Benoit, the director of the Bureau, and was concluded towards 1888. The following year the general conference of the meter again met at Paris, September 24-28, 1889, to give legal authority to these metric prototypes. The international standard was placed in a safe in a deep cellar having three locks whose keys are in the hands of three men, the director of the Bureau, the president of the International Committee, and the director general of the Archives of France. Lots were then drawn to see to which of the contracting nations particular prototypes should be assigned, and they, having been compared with the meter, will henceforth determine the unit of length for all the nations of the world.

When all these operations were finished, and the scales cleaned with hydrochloric acid, they were placed in envelopes designed by Dr. O. J. Broch. No precautions were spared to have them arrive safely at their destination. Semi-cylindrical boxes of beech wood were made, one fitting over the other, and provided with grooves lined with velvet in which the scales were laid. The whole was then put in a stout brass tube closed at one extremity and provided with a screw top at the other end which could be locked. When the various cases were properly packed each of them was transported to its final resting place in Russia, Japan, and across the Atlantic with almost royal honors. We will only mention the arrival of those sent to the United States. During the journey the delegates were responsible for the care of the cases and on their arrival were treated as persons of distinction, and directed to the White House. There the cases were unpacked in the presence of President Harrison and the principal *savants* of Washington, and a dance was improvised for the occasion. Similar methods were pursued with the kilogram. Messrs. Johnson, Mathey & Co. of London furnished the alloy for the meters, which was analyzed to be certain of its purity. After a series of weighings executed at the Normal School and the Observatory by Henry St. Claire Deville, the International Committee of Weights and Measures selected as the international prototype that one of three kilograms whose equation came nearest to that of the Archives, and inscribed it with a capital German K. This international kilogram was then taken to the International Bureau, where its volume was determined by hydrostatic weighings.

Forty cylinders were then prepared to become the national prototypes. Seventeen of these were found so defective that the chemist Debray was commissioned to remelt and correct them. Several from the staff of the Pavilion of Breteuil, and especially MM. Marey and Benoit, made the numerous determinations necessary in the study of these prototypes and their comparison with the international standard. M. Guillaume is still occupied with the study of methods of improvement. During 1898 this

able physicist published some interesting work on nickel steels, and their application to metrology. Some of these alloys have very low coefficients of expansion, are not subject to oxidation, are very homogeneous and take a fine polish. If the variations due to successive meltings are too great to allow this alloy to replace platinum iridium for the work of the highest excellence they are still so small as to allow its use of nickel steels for instruments of secondary importance.

We have now to add a remarkable undertaking of M. Michelson. This learned American by ingenious processes whose details we cannot here describe, has compared the fundamental base of the metric system with a natural unit, namely, the length of a wave of the red light of cadmium. This unit depends only on the properties of atoms and of the ether. It appears to be in the opinion of our author, "one of the most permanent magnitudes in all nature." His delicate experiments have given him the following mean values: One meter is equal to 1,553,164 wave lengths of this light at 15 degrees Centigrade and 76 centimeters pressure. So that man can say today, that if all our standards should disappear by some catastrophe, we should be able by working out the problem of Michelson in the reverse direction to re-establish by means of the results he has given us all the units of the metric system. Verily the French astronomers of the eighteenth century were not wrong in the importance they attributed to it, when they said it "was for all time and for all nations."

Notes.

BIBLIOGRAPHICAL.

The Canadian Boy (Turnbull, Wright Co., Guelph,) for September has an interesting "Natural History Corner," conducted by Prof. Lochhead, of the Ontario Agricultural College. Mr. A. W. Wright, who has lately assumed the editorial duties in connection with this periodical, deserves congratulation upon the improved appearance of the paper, which is now a beautifully printed magazine of 64 pages. Prof. Lochhead's department will give the boys of Canada an increased liking for insect and plant studies.

E. L. H.

The Canadian Forestry Association has recently issued the report of its second annual meeting. In addition to valuable papers on the problems of forestry, we are glad to notice that the educational side has not been neglected. Dr. A. H. Mackay, of Halifax, furnishes some notes regarding the teaching of some of the elementary principles of forestry in connection with manual training woodwork. And Dr. Muldrew, of Gravenhurst, has a good paper on *Forest Botany in Schools*. The report forms an attractive pamphlet of 64 pages, the cover being of appropriate and tasteful design, beautifully executed.

E. L. H.

Chemistry teachers, as well as *physiography* and *geology teachers*, have long felt the want of a book that would give just what is essential about useful ores and rock-bearing minerals. This want has been recently filled by the appearance of a little book (*The Practical Study of Common Minerals*), which bears on every page the stamp of practicability and usefulness. Mr. Hopping, the author, seems to understand perfectly the needs of the teacher, and has produced a book that is both suggestive and helpful. It not only gives descriptions, illustrated with plates and maps of the common and useful minerals, but also contains much that can be done in the laboratory in the way of tests. (It is for sale by "The School Science Press," Ravenswood, Chicago, Ill. Price, 60 cents.)

Botany teachers will be interested in a pamphlet by Mr. C. H. Robison, Oak Park (Ill.) High School, on *Outlines for Field Studies of Some Common Plants*. It was gotten out to serve as a basis for some observation work for first-year high school pupils. It is designed almost entirely for outdoor work, i. e., observations in ecology, or plant habits, and is built around material available in the autumn, a field hitherto little exploited. The work requires neither laboratory equipment nor periods of double length. In the Oak Park High School the work outlined in the pamphlet occupies the first three months, and is followed by work in the line of very simple physics and chemistry built around so-called "weather studies," all this leading up to the physiology required by law, the formal study of physiography not being favored in the first year of the high school.

BIOLOGY.

Proof of the leaf-nature of cotyledons is nicely shown in germinated Windsor beans with an epicotyl even half an inch long. They show buds in their axile, and pupils may be led to see these after learning the significance of "buds in the axile."

L M

To Study the Effect of Colored Light on Growing Organisms.—A simple substitute for the more expensive double bell-jar may be made by using two test-tubes of slightly different diameters. Place the smaller tube, containing the organism, in the larger and fill the intervening space with a colored fluid. Cover the top with a dark cloth. For a blue light, copper sulphate solution gives good results; for red, eosin. If a larger vessel is desired, slender dishes or any large glass dish may be used instead of test-tubes.

Detroit Central High School.

ELONIA ANDRE.

An Improvised Hot-Water Funnel.—Not having at hand a hot-water funnel for filtering gelatine, one was improvised in a few minutes, and the device may be of service to others. An ordinary tin funnel is provided with a perforated cork in its neck in such a position as to hold upright a smaller glass funnel inside; this allows a hot-water space between the two funnels. The lower end of the tin funnel is made water-tight over the projecting tube of the glass funnel by means of a piece of rubber tubing, wired, if necessary.

After filling the space between the two funnels with water, a Bunsen burner or alcohol lamp is set under the slant of the tin funnel, and filtering can proceed for nearly an hour without replenishing the water. A cover over both funnels will keep the water in and the dust out.

L M

Seed Distribution in the Classroom.—This is a convenient time for collecting and using dry seed-like fruits and seeds that are scattered by the wind. The means the seeds employ may be nicely shown a whole class in the schoolroom by dropping these seeds from the ceiling of the room. For this purpose one of our better pupils was given a horn scale pan, a screw pulley, some string, and an idea of what was wanted. He fastened the pulley to the moulding near the ceiling, and passed over it the string, reaching from the floor over the pulley and back to the floor. One end of the string was tied into the S-hook supporting the scale pan by three cords. The other end was fastened so as to keep it within reach. Another string was tied into one of the three holes on the edge of the pan and drawn up through the S-hook. This string was fastened to the wall at such a distance from the ceiling that when the pan was up near the pulley the pull of this string upset the pan. It will be seen that the upsetting of the pan, thus throwing out the seeds, is automatic. With a large fan the agency of the wind can be imitated while the seeds are descending.

L. M.

GEOGRAPHICAL.

The director of the geological survey of Canada states in his last report that practically nothing is known about more than a third of the Dominion of Canada. A part of this unknown region consists of the Arctic islands, but there is nearly a million of square miles of territory exclusive of these islands which is practically unexplored. Here is indeed a field for the geographical explorers and one which would seem to be more easy of conquest than the interior of Africa.

Sir Harry Johnston is reported to have discovered in Uganda a hitherto unknown animal. It is called the Okapi and belongs to the giraffe family. It is rather closely related to some fossil forms found in Greece and Asia Minor. The animal is about the size of a large ox. The color of the animal is very peculiar, the body is a reddish color, but the legs and hind quarters are striped in purplish black and white. The same explorer also reports the discovery of an ape-like people in central Africa. They have "a dirty yellow skin, a poor development of the back of the head, eyes rather close together, with prominent eyebrows, low and wrinkled foreheads. The hair is woolly, like that of the ordinary negro, though it sometimes tends to be brownish in color. The arms are long and the thumbs weak. The legs are a little knock-kneed, and are often very short in proportion to the body."

An ethnological expedition under the direction of Prof. Baldwin Spencer of Melbourne University and Mr. F. J. Gillies is studying the aborigines inhabiting Central Australia. A considerable portion of this region remains unexplored and it is very desirable that as much as possible should be learned about the manners and customs of the inhabitants, who will probably before many generations become entirely extinct.

A new Dead Sea has been discovered in Tibet by Sven Hedin, the Swedish explorer. The margin is very shallow, being but a few feet deep at the distance of over a mile from the shore. The bottom is a compact mass of salt. The entire lake is a practically saturated salt solution. The region around the sea is sterile.

Word has recently been received from Lieutenant Peary. He has circumnavigated Greenland and discovered the most northern land thus far found. He attained the highest latitude ever reached in the western hemisphere, $83^{\circ} 50'$ north. He has also determined the origin of the "floe bergs" or paleocrystic ice. Lieutenant Peary expects to remain for another year in the north and make another attempt to reach the pole.

The village of Vaglio in the Etruscan Apennines, containing 900 inhabitants, began at about 3 p. m. on March 21 to slide into the valley of the Scoltenna. The rate of sliding was about 10 inches an hour. The movement of the soil produced great waves at the front which engulfed houses and trees. During the night of the 23rd the river rose, forming a lake covering the former site of the village. The movement was so slow that the inhabitants were able to save their movable property.

W. H. S.

Book Reviews.

A Hand-Book for Teachers of Chemistry in Secondary Schools. By J. A. GIFFIN, B. A., LL. B., Collegiate Institute, St. Catharines, Ont. 12x17.5 cms., vi and 75 pages. William Briggs. Toronto, 1900. 60 cents.

The author gives a unique and original method of teaching the chemical equation, basing it upon experiment and graphic representations. Much that is suggestive will be found in his treatment. The author also gives his experience in dealing with and overcoming the difficulties of handling noxious gases, and numerous valuable hints on apparatus. Teachers of chemistry should profit much by reading this book.

Chemical Lecture Experiments. By FRANCIS GANO BENEDICT, Ph. D., Instructor in Chemistry in Wesleyan University. 13x19 cms., xiii and 436 pages. The Macmillan Co. New York, 1901. \$2.

With the spread of the laboratory method in the teaching of chemistry came a neglect of experimental demonstration by the instructor at the lecture table. The pupils must handle everything, their knowledge of the subject must be gained through their own experimental work, supplemented by a study of their text book, has been the thought and aim of most teachers. There can hardly be a doubt that this has been carried to extremes. As Dr. Benedict says in his preface: "Laboratory exercises, however great their influence in developing the experimental side of teaching the science, have their limitations, experimentally and educationally, and cannot supplant the experimental lecture, for it is in the lecture, and there only, where each experiment stands out clearly defined and unattended by the distractions necessarily accompanying laboratory exercises, that the first accurate observations of chemical phenomena can be made by students."

Perhaps another reason that lecture-table demonstrations have been neglected is the lack of a guide to them. The books of Heumann, Arendt and Newth have, indeed, been at hand, but there is a certain "foreignness" about them that seems to have stood in the way of their general use in American schools. Dr. Benedict's book, however, admirably corresponds to the limitations of our lecture-table apparatus, for it particularly tries to choose simple and readily constructed pieces of apparatus so as to tax as little as possible the teacher's time and ingenuity. The directions are plain and simple, and ensure the successful performance of the experiment. A number of novelties also are found, which put the book in advance of others of the same kind.

The book ought to find a place upon the work table of every teacher of chemistry. Many of the experiments, even if not demonstrated, can be put into the hands of students with excellent results. The book will undoubtedly prove a splendid aid to effective teaching.

C. E. L.

A Laboratory Course in Plant Physiology. By DR. W. F. GANONG, Professor of Botany, Smith College. 15x22 cms., vi and 147 pages. Henry Holt & Co. New York, 1901. \$1.

This book provides an excellent course of laboratory work in plant physiology designed to cover a college year. The author, who at the same time is a most effective teacher, has plainly put much time and thought on the matter before printing the book. The experiments outlined can be performed to a large extent with apparatus that can be provided at moderate expense and bears witness to much ingenuity in their designing. The plan of the work is drawn in decided lines and a marked character is thereby imparted to the book which will challenge the attention of the thoughtful teacher. All in charge of botany in high schools in which the newer methods have found foothold, will find much to reward an examination of Dr. Ganong's book.

RODNEY H. TRUE.

Practical Text Book of Plant Physiology. By DANIEL T. MACDOUGAL, Director of the Laboratories of the New York Botanical Garden. 13x21 cms., 252 pages. Longmans, Green & Co. New York, London and Bombay, 1901. \$3.00.

The lack of suitable elementary English text books dealing with the fundamentals of Plant Physiology has been increasingly felt by instructors in botany as this phase of plant study has come more and more to the front. This book, presenting, as it does, a concise discussion of the underlying principles and directions for a course of laboratory work, aims to meet the need felt. The work is essentially a book for use in college grades, and will prove very suggestive for science teachers in the secondary schools.

The discussion proceeds from a thoroughly modern standpoint and the citations of recent work will prove very useful. Some unfortunate errors have crept in which should be corrected in later editions. The laboratory experiments are on the whole well selected and clearly outlined. In every way the book marks a distinct advance over the author's earlier book on the subject.

RODNEY H. TRUE.

Sylvan Ontario. A Guide to Our Native Trees and Shrubs. By W. H. MULDREW, B. A., D. Pæd., Principal of the High School, Gravenhurst, Ontario. 14x20 cms., 70 pages. William Briggs, Toronto, 1901. 50 cents.

This useful little volume is the result of practical educational work done by Dr. Muldrew. Many readers of SCHOOL SCIENCE will remember

a paper on "*Forest Botany*," appearing in the April issue. Owing to encouragement received from all quarters, Dr. Muldrew has now put into available form his scheme of identification of trees and shrubs by their leaves. The essential part of the book is "An Index Based on the Leaves," which is used in the same way as a botanical key. This index is preceded by a synopsis of leaf and stem terminology, which is illustrated by references to the numerous outline drawings which appear as alternate pages of the index. These outline drawings are of assistance to the pupil in his diagnosis. The index is followed by a list of shrubs and trees, containing appropriate notes on each.

The prevailing ignorance in regard to our common trees ought to disappear if the book continues to meet with the wide sale which it merits. It has already been put to the test by several teachers of experience and has been found to give excellent results in the hands of even junior pupils. A very little instruction ought to enable a boy or girl to use it intelligently.

Though the author has called his book "*Sylvan Ontario*," its usefulness is by no means confined to the province. The similarity of the floras of neighboring states will make it useful for a very large portion of the continent.

Besides the cloth covered edition, the publisher has issued a very artistically bound edition in soft leather, at one dollar. The press-work and paper are all that can be desired. The work is highly creditable to the publisher whose advertisement appears in this issue.

E. L. H.

Foundations of Botany. By JOSEPH Y. BERGEN, A. M., Instructor in Biology in the English High School, Boston. 13x19x37 cm., xi and 412 pages; with which is bound *Bergen's Botany, Key and Flora*, ii and 257 pages. Ginn & Co. January, 1901.

This book is avowedly an amplification and revision of the author's *Elements of Botany* issued several years ago. The success of the earlier work was evinced by the ready sale and wide distribution which it enjoyed. This condition has brought to light many suggestions and ideas now more or less fully incorporated in the new work. The first part of the book is concerned with the structure, physiology and classification of plants. The study of the structure and physiology begins with the seed and its germination, and passes more or less regularly through the developing parts of higher plants to the mature fruit. The great feature of Mr. Bergen's treatment of these related subjects is truly pedagogical, quite in contrast to their separation in many modern botanies, and to the methods of as many secondary schools claiming to be up with the times. He makes a great point of structure and function being interdependent and simultaneous. He has gone on the principle of showing that structures are for a purpose, and that functions are carried on by these very structures. Between the

study of leaves and the study of inflorescence, the author has introduced a chapter on "Protoplasm and its Properties," which produces a perceptible break in the first eighteen chapters. From the point of view of construction, it would have been better to have placed this chapter either before or after those mentioned, leaving more evidently to the choice of the teacher the introduction of this chapter according to the conditions of the course. The classification of plants is discussed in a short chapter, in general, together with two tables illustrating the use and value of the taxonomic terms "cryptograms," "thallophytes," "gymnosperms," "class," "order," etc. The remaining four chapters treat of the structure and somewhat of the actions of representative types of flowerless plants, together with a short discussion of the history of plants in time. Now it would seem that the student should be led by stages through these groups, and then to the broader question of plant relationships. This logically would place the chapter on classification at the end of Part I. A marked improvement of this book over its predecessor is the fuller treatment of, and the added experiments illustrating, plant activities, and in a fuller complement of cryptogams. There is now a better balance between seed plants and spore plants, there being no doubt the educational value of the study of one is as great as of the other group.

Part II. is concerned with "Ecology, or the Relations of Plants to the World About Them," "Plant Societies," "Botanical Geography," "Parasites," "Carnivorous Plants," "How Plants Protect Themselves," and others, are the chapter headings. A chapter on "The Ecology of Flowers" deals not so much with the flowers as a whole as with modifications of their parts for their pollination through the agency of wind, insects, etc.; and, in contrast to these, with cleistogamous flowers. The season of the year, the advancement of the class, and the accessibility of the fields must determine the introduction of these problems of ecology into the other parts of the course. Any bright teacher would instantly see that plant ecology has close relations with structure and activity. This part was in some degree included in the general part of the *Elements of Botany*, but now, following the lead of other recent authors and botanics, is separated from the other subjects, presumably for the emphasis now being given to the ecological side of Nature Study.

The Key and Flora comprises about 700 species belonging to the gymnosperms and angiosperms. It is gratifying to see that after studying about plants from the known to the unknown, the student is given the use of a manual descriptive of them, which is arranged in the order of the simplest to the highest, thus calling his attention to their true relationship. The classification used is practically that of Engler & Prantl. The nomenclature is, with a few exceptions, that of Gray's *Manual*. One condition of this nomenclature is without apparent consistency or explanation, viz., the capitalization of specific names derived from the names of men and names of genera other than those containing the said species, while specific

names derived from geographical ones are not capitalized. This *Flora* is illustrated, in connection with the keys, by figures representing the more complex and less understood structures. The keys in the main are artificial. With the fuller treatment of the cryptogams in the text-book, there seems to be a lack in the *Flora's* not containing at least some forms of the flowerless plants. The educational value of the determination, if not farther than to genera, of fernworts and the larger mossworts, particularly after the study of their morphology, is as great as in classifying flowering plants, to say nothing of the additional knowledge.

The typography and illustrating are a great improvement over the older work. The binding of the copies we have seen, while artistic, is hardly suitable for the unavoidable soiling in laboratory and field.

E. L. M.

CLEARING HOUSE.

Teachers desiring to offer for exchange books, apparatus, etc., may insert a notice to that effect at the nominal rate of one cent per word, *in advance*.

Reports of Meetings.

N. E. A. ROUND TABLE CONFERENCE IN PHYSICS.

THURSDAY, JULY 11, 3 P. M.

Mr. Carl I. Ingerson, Normal and High School, St. Louis, *Leader*.

Mr. H. D. Minchin, Central High School, Detroit, *Secretary*.

The conference was called to order by the chairman, who, after stating the object of the meeting, read a paper entitled, "Physics in Secondary Schools." (See page 288.)

Discussions were now in order and the following are in brief the remarks of the different speakers:

Mr. A. W. AUGUR, Lake View High School, Chicago: "In my remarks I wish to speak briefly of two tendencies at present existing in the teaching of physics.

1. At present there is a crowding of too much work into the course. We attempt to teach too much for the time we have at our disposal. We

are crowding two years' work into one. The result is that work is not done well; there is a skimming over. It is absolutely necessary that the student be given more thorough drill and therefore he should not be overcrowded. It is for the teacher to carefully select that which is to be given him and that which he is to overlook. The time at present given to physics in the high school is not sufficient to allow the taking up of the whole subject of physics.

2. The present method of dividing the subject matter into heads, as Mechanics, Heat, Sound, etc., is misleading to the student. He comes to think of the study as a collection of several subjects. We must get an underlying principle, one that we may cling to in the different sub-heads. At the present I am working for such a plan and I take as the definition of physics the following: It is the science that treats of the motions of matter, all motions being considered as the result of the action of forces, and all forces as the manifestations of energy. If we keep this definition in mind it changes the order of presenting the subject.

We will not take up the properties of matter first but will begin with motion. The pupil never saw a case of uniform motion; there is no such thing as pure mechanics or pure dynamics. We should take as our first example of motion a vibratory motion. This is almost exact and can be measured. Discuss uniform motion as growing out of this and sound as a particular kind of uniform motion; heat also as a particular kind of the same phenomenon, etc. This will unify the work and keep it within our limits.

In regard to laboratory experiments I hold that there are but two reasons for performing an experiment:

1. It illustrates a law.
2. The results obtained by performing it are essential for future experiments.

Do not ask the pupil to perform experiments that are of neither class. Do not ask him to measure a piece of wire unless he is to use the wire and needs to have its length. He should learn how to use it in a practical exercise.

As to the amount of laboratory work we are in great danger of asking the pupil to do too much. We should aim to have him do a few exercises well rather than a number and do them with no idea of what they may mean or of what use they are."

MR. E. A. THORNHILL, Carrollton, Ind.: "I am at present endeavoring to re-organize my work in physics and I wish to ask what amount of time should be given to laboratory practice."

MR. C. F. ADAMS, Central High School, Detroit, Mich.: "I heartily endorse the paper to which we have just listened. I think much better results would be obtained if we were to begin our work with motion and we should not be afraid to begin here.

I believe we have better results from our laboratory if we keep in

mind that there are many facts and truths that are now well established and need no further proof by the pupil.

In answer to the question just asked I will say that we have four recitation periods per week for text work and two periods per week for laboratory work. We should have more time. We ought to have five recitations in the text, as we now have to take one of the four for discussing the laboratory exercise of the week. Then we should have at least two periods of 60 minutes each per week for laboratory where we now have but two of 45 minutes each. In this state we have laid down as a minimum amount of work for the laboratory a list of about 40 experiments. The time now given to these is not sufficient to cover the work as I think it should be covered. Our work lacks in completeness. We lay a good foundation, but the superstructure is lacking.

In speaking as I am, I speak not as a teacher of physics only, but as a teacher interested in the high-school course. In the small schools where much individual work can be done more may be accomplished in the same time."

MR. H. N. CHUTE, Ann Arbor, Mich.: "My sympathy is with the paper just read and I am glad of the interest shown in the points called forth.

Our great difficulty with the subject of physics is that the boys and girls think they have taken hold of a new language. They get the idea that it is a compilation of hard words. It is in a sense a foreign language to them. The sentences that are plain to us are, it may be, meaningless to them.

We must translate this language for them and then require them to translate it back into the language of physics.

We experience other difficulties in the teaching of physics because of the fact that it is placed too low down in the course. The average boy and girl reach the 11th grade at about 15 and their minds are not mature. They are unable to grasp the subject. They get the idea that physics is a grind. The subject has been given a black eye long before it is reached and it takes a good half year to remove the fear that has seized the pupil. The parents and often the principals are to blame; they are anxious to crowd the pupil and he is not given the time to comprehend the facts. A lack of interest is the result.

I wish to emphasize what the paper stated regarding the amount of time given to the different parts. The boy is interested in the magnet and he wants his work all electricity. There is a tendency to skim over light and heat. Both the latter are of great importance and both can be illustrated easily and at small expense.

As to what experiments to perform I would like to ask where the pupil will land if he is to perform no experiment only that one, the results of which he is to use in the next experiment.

In my work I give 4 periods of 55 minutes each per week to text and 3 periods of 55 minutes each per week to laboratory.

I follow the outline prepared by the Michigan Schoolmasters' Club in 1899."

MR. C. F. ADAMS "I heartily endorse the point that no work should be required of the pupil if it is to be of no use to him. Do not have him measure for the mere sake of measuring."

MR. HERBERT C. WOOD, Cleveland, Ohio: "In reference to the mathematical preparation of the pupil with us no pupil is allowed to take up physics until he has had one year of algebra and the same of geometry.

Some of the difficulties I have met in the teaching of physics I find are due to the indifferent work done in the preceding studies. It is necessary that in geography, botany, physical geography, etc., more scientific work be done. We have in our schools introduced laboratory work in connection with physical geography and we find that better work is being done in physics."

MR. JONES, South High School, Cleveland, Ohio: "Our requirements are the same as those of the Central. We have physics in the third year. I find a difficulty in getting the pupil to state in mathematical language an expression in physics and *vice versa*. The teacher of physics has as his first duty to teach how to change from a statement in physics to one of mathematics. Secondly he must teach that mathematical expressions do not teach that we can get at a thing exactly. The pupil sees in the laboratory that we can not get at an exact result."

PROF. F. A. OSBORNE, Olivet, Mich.: "As teachers we are too often afraid of having physics considered difficult. If we are to make the study intensely interesting and give the pupil the discipline he should get from it we must make it difficult. It is possible to add new interest and not detract from its value. It is well to introduce some historical facts. In every study there is encouragement in knowing of the difficulties others had with the subject. Devote one-half hour per week at least to the history of the subject.

As to the use of problems in physics I find they are of untold value. My students work 250 to 300 problems each year and benefit by so doing.

Do not leave out the original work. We do not do so in geometry. The more we make physics difficult and not a grind the better. In the laboratory work I believe in doing fewer experiments and doing them well. I began by working 60, I now work about 40. I am decidedly in favor of working a few experiments the data of which are not required later."

MR. A. P. COOK, Ithaca, Mich.: "I have a laboratory about 12x25 for 25 pupils. Ours is about a middle high school and we are placed under many restrictions. Our work must be shaped accordingly. I am in favor of working many problems. I believe in making the subject hard. Do not attempt to dodge all the hard points, but solve them and derive the

benefit. Tell the boys and girls to keep their eyes open and be ready to apply what they have learned."

MR. H. N. CHUTE, Ann Arbor, Mich.: "The question that troubles me is where to get the wherewith to teach physics. I mean good and efficient instruments. Our foreign friends make them, but Uncle Sam says we cannot have them unless we pay large tribute. Our lawyers seem to be unable to interpret the law. They do not understand English. They fail to be able to recognize a scientific instrument. We should look up the law and then translate ourselves into chronic kickers. It is time for the scholar to get into politics."

MR. ADAMS: "It seems that some protest should be made by the N. E. A. and I therefore move that we enter a protest and present it to the Secretary and Treasurer of the U. S. and that our chairman appoint a committee to draw up said protest and present it to the proper authorities."

The motion carried. Chair appointed Messrs. Adams, Augur and Wood, the committee to report at the meeting July 12. It was suggested by Prof. Osborne that each member of the Physics Conference present to his Congressman a copy of the report of the committee, together with his own letter. The suggestion was favored by those present.

Correspondence.

CIRCULATION OF BLOOD IN A FROG'S FOOT

In SCHOOL SCIENCE (Vol. I, page 219) it is suggested cutting the head of a frog off and wrapping it in a wet cloth to demonstrate circulation. This is a good method, but I have always simply wrapped the frog in a wet cloth, leaving one hind leg exposed. Then I lay it on a glass plate about 7x9 inches, supported by the stage of the microscope and a chalk box. In this way I have had no trouble in keeping the frog quiet, and, of course, could use the frog day after day as long as desired. The frog's foot will adhere to the glass so that there is usually no trouble in keeping the web stretched. Sometimes, however, I have stretched out the web and laid a glass slide on the ends of the toes. This may be fastened down with two pinch-cocks provided with small rubber tubing over the jaws to keep them from slipping off the glass.

Hope College, Holland, Mich.

S. O. MAST.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion, as well as answers to the questions of others. Those of sufficient merit and interest will be published.

DISCUSSION OF QUESTIONS.

26. *What is the best material for a chemical table top—wood, glass, tile, soapstone, or what?*

If it can be afforded, soapstone tops are by far the best for a chemical table top. I have now had in use for three years soapstone tops (of the variety known as "Albarene") and they are not merely practically but are actually as good as new. Chemicals and heat seem to have had no action upon them. They can be made to look as good as new by application of sandpaper once or twice a year. The objection which might be raised that they are too hard and that glassware is easily broken on them, my experience does not sustain. The side tables in my laboratory are of slate, and it is quite noticeable that glassware used on them is liable to be broken by setting it down a little too hard, although nothing of the sort is observed on the soapstone tops. Slate, by the way, cannot be recommended. Apart from its hardness on glassware, it is attacked slightly by acids, so that it soon scales off, leaving a rough surface. Glass tops I have had no experience with, but would think that they would be liable to break from heat or strain, and would soon be all scratched up without the remedy of sandpaper. Wood tops are, however, not to be despised. Even a soft wood like pine, if rubbed over with hot paraffine from time to time, proves very serviceable, and hardwoods, especially sycamore and oak, can withstand quite rough usage for a long time. Tile tops if well laid are excellent, if poorly laid, a nuisance. They are especially to be recommended for side tables in front of a window where volumetric work can be done, as in titration, the white surface aids in sharply distinguishing the end reaction.

C. E. L.

28. *Does the presence of iron, as gas pipes, bolts, etc., in a physical table top interfere with the success of the experiments in electricity and magnetism given in the usual course in elementary physics?*

No, if the apparatus when once set up is not moved to another part of the table. Galvanometer needles may indeed not point north, but they will point in some definite direction, and as long as the magnetic substances influencing the needle are not displaced, that direction will be maintained. Of course, with certain delicate magnetic experiments, proximity to iron, etc., is not permissible, but these experiments are not suited for the high-school laboratory.

C. E. L.